The demand on the part of artillerists, aviators, and many other military units for weather information and forecasts has demonstrated that meteorology is a subject worthy of the time of more than a mere handful of investigators. The growth of aviation alone and the promise it holds points to a quick rise of interest in the study of the physics of the air. Students who desire to specialize in meteorology need no longer be told that the master or doctor of meteorology must look forward to probable unemployment in his chosen field of work.

Specifically, what are some of the lines of work demanding services of meteorologists? Business, farming, transportation, aviation, research and teaching all need men who know meteorology. Large business concerns have men who constantly watch the weather from the point of view of its effects on their work. For example, general merchandise and hardware concerns buy stock with a view to the probable demand for the different lines several months later; a demand which for many lines of goods is closely dependent on the weather. Without making a study of present and probable weather,[22] these concerns would lose much by having an excess of one kind of stock and not enough of another.

Every farmer is his own local forecaster, and usually he is a good one, for his outdoor life and his direct interest make him familiar with the weather. A large farming corporation, however, needs more than the indications from local signs. A meteorologist to direct the farming, storing and shipping operations would save much produce in the course of the year, and would be able to have the goods reach the markets at the times when prices are best. At Medford, Oreg., in 1912, the fruit growers employed their own frost expert.

Railroads, particularly street-railway companies, have every reason to want in the traffic department a man who knows some meteorology.[23] The question frequently arises, "Snow is forecast for to-night—shall I hold 1,000 men ready to clear the tracks? They would be needed only if the fall exceeds 2 or 3 inches." Motor-truck freight companies in their operations depend considerably on the weather.

In aviation, the wind directions and velocities at different elevations are of great concern. For instance, a wind of 60 miles an hour is to be sought if it blows toward the aviator's goal; but avoided otherwise. To keep informed of the winds of the free air all over the United States will require observations of pilot balloons a few times daily at perhaps 100 places.[24] To chart, and to study these observations will require the work of a large number of men. The openings for aerologists are limited only by the expansion of flying.

The highest specialists in meteorology are needed for research work and teaching. Some subjects worthy of research are indicated in the list on pages 566–567 of this issue of the REVIEW. Research workers would be supported mostly by the universities,[25] by business men, or by the Weather Bureau. To meet the growing demand for meteorologists, there is imperative need of an increasing number of teachers of meteorology.

[22] See "Relation of weather and business in regard to rainfall," Special bulletin, Chamb. of Comm. of the U. S. A., Washington, D. C., Feb. 14, 1919, 4°, 12 pp.

[23] Every November the New York Central Railroad issues a "Chart of mild and cold winters," for the winter guidance of maintenance of way engineers and rolling stock superintendents. The Sixth Annual Weather Issue (by P. H. Dudley, consulting engineer, rail, tires, and structural steel, New York, Nov. 14, 1918), contains a letter; a table of monthly mean temperatures at 16 stations; a chart of departures of monthly temperatures from these means, 1911–1918; and a mention of the operating character of each winter.

[24] There are now only about 30.

[25] In the American Meteorological Journal are articles by Cleveland Abbe on "The needs of meteorology" (1893, XI; 560-562), and "Meteorology in the university" (1896, XII; 312-317), which call for the endowment of universities for meteorological work on a scale commensurate with astronomy; and which outlines a thorough course in such an establishment.

A SIGNAL CORPS SCHOOL OF METEOROLOGY.[1]

By OLIVER L. FASSIG, Chief Instructor, Signal Corps, U. S. Army.

[Dated Washington, Dec. 25, 1918.]

The value of an intimate knowledge of weather conditions—actual and prospective—in war operations is obvious. The many practical applications of this knowledge in artillery fire, in aviation, in gas and flame attacks, in bombing expeditions, and in many other military and naval operations, have received special attention during the past year in the Signal Corps of the Army. One of the duties of the Science and Research Department of the Army is the supervision of all research and development work in meteorology, under the direction of Lieut. Col. R. A. Millikan. By special mention this includes the furnishing of information of surface and upper air conditions to all branches of the Army, and the training of all meteorological personnel.

Early in the fall of 1917, a meteorological section of the Science and Research Department was planned and steps were immediately taken by Col. Millikan, in cooperation with Prof. C. F. Marvin, Chief of the Weather Bureau, to form an organization to provide for the necessary special training of approximately 1,000 men, and for procuring the essential instrumental equipment for stations. The only existing source from which trained weather observers could be drawn was the United States Weather Bureau. As the bureau had already contributed a considerable number of its observers to various branches of the military and naval service, any additional withdrawals would seriously cripple the essential work of the Bureau. Hence plans were made for the special induction of the needed men into the Signal Corps for training and service as weather observers.

As time was a matter of prime importance, the first contingencies of inducted men were sent to a score or more of Weather Bureau stations, located in all sections of the country, in groups of two or three, to eight or ten. Here they were given practical instruction for a period of eight to ten weeks in the duties of observing and recording weather conditions, in the preparation of forms, in the use and theory of instruments, and in the preparation and interpretation of weather maps, under the supervision of the official in charge of the station. In this manner about 200 men were prepared for duty overseas and in this country between September, 1917, and April, 1918. Upon arrival in France the men were given an additional short course in review and in such new applications of their knowledge as were developed at the front.

The instruction at the stations of the Weather Bureau was intended only as a provisional plan to obtain quick results. Early in the spring of 1918 a special school for the training of the men was organized, as it was evident that better results would doubtless be obtained, and with less inconvenience to the Weather Bureau, by standardizing the course of instruction and collecting into one school and under one instruction staff as many men as could be satisfactorily provided for under existing conditions. The first class was organized at Camp McArthur, Waco, Tex., in April, 1918. Before completion of the organization the school was transferred to the Agricultural and Mechanical College of Texas, at College Station, in the latter part of May, 1918. The instruction staff consisted of:

Dr. Oliver L. Fassig, Chief Instructor and Director.

Dr. Charles F. Brooks, Instructor in general meteorology and cloud observation.

[1] Read at the Baltimore meeting of the Association of American Geographers, Dec. 28, 1918.

Mr. William T. Lathrop, Instructor in instruments, observations, and weather maps.

Lieut. William S. Bowen, Instructor in aerology.

The character of the men of this first school of meteorology organized for war work may be of some interest. In the call for men for this service Col. Millikan emphasized the need of men with a college training and especially of such as had a knowledge of mathematics and the physical sciences, or were trained as civil, electrical, or mechanical engineers. As a result there was brought together at College Station, Tex., a class of about 300 enlisted men from 21 to 31 years of age, excellently equipped, mentally and physically, to be converted into observers during a brief period of intensive training occupying about three months. Practically all of the men were either college graduates or had had several years of training as observers in the United States Weather Bureau. Over 100 of them were civil engineers; about 75 were mechanical or electrical engineers; 20 were chemists; about 40 were trained observers from the Weather Bureau; and 30 or more were teachers of science and mathematics. Altogether about 100 colleges were represented including all of the larger institutions of the country. Much valuable assistance was given by the best equipped of these men, who were made assistant instructors.

The men were housed in modern college dormitories, and provisioned at the college mess hall; while President Bizzell and his colleagues of A. and M. College made most liberal provision in the way of class rooms and equipment by placing the civil engineering building at the disposal of the school.

The men were kept busy at their studies and daily military tasks from sunrise until 5 p. m., with an additional study hour or two between supper time and taps. Military administration and instruction were provided for by four commissioned officers of the Signal Reserve Corps, with Lieut. Hjalmar B. Hovde as commanding officer, assisted by Lieuts. A. M. Lindsay, A. W. Hall, and E. A. Wagner. The daily schedule of technical studies included a lecture in general meteorology or aerology; frequent daily cloud studies in the field; the construction and interpretation of the daily weather map, based upon telegraphic observations, for forecast purposes; daily observations such as are made at a first order station of the Weather Bureau; the preparation of meteorological and aerological forms; and thorough practical field instruction in the use of a theodolite for determining the paths of small rubber balloons filled with hydrogen, for determining the velocity and direction of the winds to great elevations above the ground.

The aerological work, dealing with upper air conditions, particularly interested most of the men, especially the engineers. The high grade of men composing the class made it possible to suggest many new mechanical devices and to develop new and quick methods of reducing observations for determining the ballistic wind—methods which will prove to be of great practical value to the artillery units of the Army. The results of their work will not only give more accurate values for the atmospheric factor in firing, but will greatly reduce the time required in obtaining these values—matters of utmost importance in operations at the front. The projectiles fired from the big modern guns not only cover a horizontal distance of 30 to 40 miles, but they traverse the upper atmosphere to heights of many miles. The projectiles of the super-gun which was trained upon Paris at a distance of 72 miles must have reached an elevation of from 30 to 35 miles, exceeding the greatest elevation reached to date by means of pilot balloons. Wind velocities along the path of projectiles may vary from a few miles to 40 or 50 miles and more per hour, and the upper winds may be directly opposite in direction to those below. It is evidently necessary to know accurately the conditions through which the projectile passes, and to get this information quickly. Until very recently it was assumed that surface atmospheric conditions prevailed throughout the path of the projectile, and no allowance was made for the great variations in temperature and density of the air and wind direction and velocity, which actually prevail and which must greatly influence the path of the projectile.

The pilot balloons generally used for this purpose are small rubber balloons, 6 inches in diameter, filled with hydrogen until distended to a diameter of 20 to 30 inches. They are set free, and the position of the balloon in azimuth and altitude is observed at intervals of a minute or more by means of two theodolites placed at the ends of a base line of known length, varying from half a mile to 2 or 3 miles, according to local conditions. This reduces the determination of wind velocity and direction to simple trigonometric computations. These balloons may be observed to great elevations and distances in clear weather. In the latter part of June, 1918, at College Station, Tex., the position of one of these balloons was observed in altitude and azimuth every minute for 172 consecutive minutes, before it faded away, or probably collapsed. It had reached an elevation of 22 kilometers and a horizontal distance of 20 kilometers. The use of such balloons in recent years has added much to our knowledge of varying conditions of the atmosphere up to a height of 25 miles, and to our knowledge of atmospheric processes at great elevations, at comparatively small cost. The knowledge thus gained is of great value to the aviator, especially in selecting favorable air routes, and will aid in the progress of development of aviation to an increasing degree in the near future.

An intimate knowledge of the temperature and density of the air, and of changes in wind velocity and direction, is indispensable for accurate artillery fire, especially in the operation of long range and anti-aircraft guns. Speed in delivering accurate data to the artillery units is of the utmost importance. By means of methods developed at the training school and at the numerous local stations established in connection with artillery and ordnance camps and flying fields in this country, the mean velocity and direction of winds in successive zones of 500 meters may be obtained within less than five minutes after the time the balloon has reached the maximum elevation desired.

One of the important problems, in the solution of of which the members of this class rendered valuable service, was the development of an improved empirical formula for determining the rate of ascent of a balloon from observations by means of a single theodolite in place of two theodolites.[1] This reduces the necessary instrumental equipment and the size of the station force. Much time in reducing observations was saved through the employment of quick graphic methods in computing the ballistic wind in place of the slow and tedious methods of computation previously in use. Another product of the school is a weather map 6 feet long. It is the familiar daily weather map of the United States Weather Bureau, enlarged and modified for classroom instruction. It can be prepared in from one-half to three-fourths of an hour, depending upon the skill of the operator.

[1] To be discussed in an early issue of the REVIEW.

At the time of the signing of the armistice about 300 men, trained at Weather Bureau stations and at the school of meteorology in Texas, had been sent overseas; and about 200 men were assigned to a score or more of the flying fields, artillery and ordnance camps, balloon schools, and radio detachments in this country, for the purpose of supplying these branches of the Army with the meteorological data desired. A score or more of the graduates of the school who are stationed at headquarters in Washington engaged in the reduction of field observations, in the charting of upper air currents, and in necessary administrative duties. Twenty-five of the members of the class were transferred to the Navy for duty in connection with the development of the hydrophone, an instrument designed to detect the presence of submarines.

The School of Meterology was not a unit of the Students' Army Training Corps. It was organized and maintained under the direct supervision of the Chief Signal Officer of the Army.

NEW METEOROLOGICAL BOOKS.

Physics of the Air.

The most thorough American work on general meteorology which has appeared for many years is Prof. W. J. Humphreys's, Physics of the Air. Part I, on Mechanics and Thermodynamics of the Atmosphere (also, atmospheric electricity), was published [1] in 14 installments, making 402 pages, in the Journal of the Franklin Institute, 1917 and 1918. Some 300 copies of Part I will be made up in book form. The purpose of the work is to present a comprehensive, explanatory statement of the physics of the air; one which may form the basis for new courses in meteorology in college and university departments of physics. Much of the argument is developed by the author; in fact, almost without exception the formulas used are derived in the text. Where further information might be of value, Prof. Humphreys not only has given detailed references to the comprehensive literature on meteorological physics contained in the Weather Bureau library, but he has also incorporated digests of these articles and works in his discussion. Thus the reader does not need to look up the references unless he wishes to make a special study in any line.

The scope of the book is all that is implied in the title, the physics of the air. In the first chapter, the sources of meteorological information and the interrelations of the meteorological elements are discussed and illustrated. Then follows, chapters 2 to 6, a careful mathematical exposition concerning the temperature, composition, and heating of the atmosphere. Particular attention is paid to adiabatic changes, to the vertical distribution of temperature,[2] and to the cause of the isothermal condition of the stratosphere.[3]

The middle third of the book, chapters 7 to 10, comprises a thorough exposition of the winds, which are classified according to their immediate causes: (1) local heating; (2) cooling; (3) local heating and cooling; (4) widespread heating and cooling, and (5) external force. Group 1 includes sea breezes and valley winds. Group 2 comprises land winds, mountain winds, and all sorts of fall-winds. Group 3 is of thunderstorm winds. Group 4 involves cyclones and anticyclones, continental winds, and the planetary circulation of the atmosphere; and group 5 includes forced winds, tornadoes, and the foehn. Although each teacher of meteorology will prefer to make some changes in this classification, probably by combining groups 1 and 2, at least, this new classification of winds on the basis of immediate causes has been found better for instruction than a classification based on the original source of energy.[4]

Chapter 11, on barometric fluctuations, contains an explanation of barometric "ripples" and a rather full description and explanation of the diurnal and semidiurnal pressure changes.[5] In chapter 12 the author presents in some detail the rather intricate subject of evaporation and condensation. Fogs and clouds, in chapter 13, are discussed too briefly to do justice to these visible signs of atmospheric processes; the explanatory descriptions and the carefully selected cloud pictures are well worth double the space accorded them. The thunderstorm, in chapter 14, receives the space appropriate to such a commanding phenomenon. It is considered as a whole, and each of its elements, especially lightning,[6] are treated in detail. In the following chapter, the scattered results of investigations in atmospheric electricity are bound together. A detailed outline of the history of the development of our knowledge of the subject is given in the first two pages. Then follow in succession brief, though explicit, treatments of the electrical field of the earth, the electrical conductivity of the atmosphere, ionic content of the air, electrical currents in the atmosphere, radioactive content of the atmosphere, penetrating radiation, and origin and maintenance of the earth's charge. A brief discussion of the aurora closes Part I.[7]

Since the present edition is so limited the work is not yet readily available. Nevertheless, Prof. Humphreys has made it no longer necessary to go to works in a foreign language for books on advanced meteorological physics. A review in Nature (London, May 23, 1918, p. 231) says:

> For the large number of readers interested in the fundamental facts of meteorology, there has, up to the present, been no trustworthy text-book which discussed the subject from so scientific a viewpoint or dealt with its modern developments so completely.—C. F. B.

Manual of Meteorology.

Part IV of a voluminous manual of meteorology by Sir Napier Shaw has just appeared (Cambridge, England, 1919).[8] In the preface the author mentions the contents of the different parts to be as follows: I, A general survey of the globe and its atmosphere; II, The physical properties of the air; III, The dynamical and thermal principles upon which theoretical meteorology depends; IV, The relation of the wind to the distribution of barometric pressure. A more extended notice of this work will be published in a later issue of the REVIEW.—C. F. B.

Introductory Meteorology.

As a text or reference book for the Students' Army Training Corps, Introductory Meteorology was written by officials of the Weather Bureau at the request of Prof. H. E. Gregory, representing the National Research Council. The manuscript was prepared in a fortnight in August, and the book appeared from the Yale University Press in October, 1918. (8vo., 149 pp., 71 figs., $1 gross.) Chapters I, the Atmosphere; part of IV, Atmospheric Pressure; V, Evaporation and Condensation; and VI, Fogs and Clouds, are taken largely verbatim from Prof. Humphreys's, Physics of the Air; and Chapters VII, Atmospheric Optics, and VIII, General Circulation of

[1] Published by the Franklin Institute in cooperation with the Weather Bureau.
[2] Cf. pp. 564–565 of this issue of the MONTHLY WEATHER REVIEW.
[3] Cf. p. 564 of this issue of the MONTHLY WEATHER REVIEW.
[4] Cf. W. M. Davis, Elementary meteorology, Boston, 1894, p. 112.
[5] Cf. p. 565 of this issue of the MONTHLY WEATHER REVIEW.
[6] Ibid., pp. 565–566.
[7] Cf. the outline and discussion of the arrangement of the work as a whole, ibid., p. 558.
[8] Pts. 1–3, not yet issued, pl. 4, 4°, 160 pp.